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DIVISION OF HIGHWAYS
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Mr. J. L. Beaton
Chief Engineer, Transportation Laboratory

I have reviewed and now submit for your approval this interim research report titled:

AGGREGATE FILM STRIPPING STUDY

Study made by . . . . . Pavement Section

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Very truly yours,

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**16 ABSTRACT**

An investigation of the effectiveness of lime slurry and Emery 6856 to control excessive stripping and swelling of asphalt concrete containing a problem aggregate is described. Various tests and measurements were made in the Laboratory that included Stability, Cohesion, Specific Gravity, Swell, Expansion, Resilient Modulus and Abrasion Resistance.

It was concluded that lime slurry treatment of the aggregate would have a beneficial effect and that the Emery 6856 provided no significant improvement of the asphalt concrete properties studied.

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## ACKNOWLEDGMENTS

We wish to express our appreciation to the personnel of District 09 for their cooperation in obtaining data for this investigation.

The contents of this report reflect the views of the Transportation Laboratory which is responsible for the facts and the accuracy of the data presented herein. The contents, however, do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

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## I. INTRODUCTION

In many areas in California there exists an acute shortage of good quality aggregates for asphalt concrete mixes. Often, marginal aggregate sources must be used to eliminate the high cost of importing aggregates from sources far removed from the specific area. One such source of poor aggregate is located near Inyokern, California, and is referred to as the Bowman Pit. Asphalt concrete pavements containing aggregate from this source have had a history of poor performance. Generally, the type of distress that has occurred is "stripping", which has then resulted in raveling of the pavement and subsequent pavement failure.

In January, 1974, the Pavement Section of the Transportation Laboratory was informed that the Bowman Pit was to be used as an aggregate source during the summer of 1974. At the request of District 09, the Pavement Section conducted a series of tests to determine if an additive to the aggregates from the Bowman Pit could be used that would control excessive stripping. This report contains the results of this testing program.

## II. CONCLUSIONS

From test data it is concluded that:

1. Emery 6856 in the concentrations studied had no beneficial effect on the properties of the asphalt concrete examined.

2. Lime slurry treatment of the asphalt concrete aggregate had a beneficial effect on the properties of the asphalt concrete studied.

3. The low flash point (270°F) of Emery 6856 would make this a dangerous additive to use.

## III. RECOMMENDATION

From evaluation of all test data, it is recommended that 2 percent hydrated lime in a lime slurry be used as an additive for all asphalt concrete mixes produced with aggregate from the Bowman Pit.

## IV. IMPLEMENTATION

The results from this study as well as the results previously published(1), will aid in drafting new specifications leading to the use of additives for marginal aggregate sources to improve their physical properties.

## V. DISCUSSION

The additives that were used in this laboratory study were a lime slurry and Emery 6856, a commercial product. A slurry was made by adding 1 part hydrated lime to 3 parts of water. The residual amount of hydrated lime used was 2 percent by dry weight of the aggregate mix. The lime slurry was thoroughly mixed by hand with the blended aggregate and left to dry. After drying overnight in a 140°F oven, the optimum asphalt content for this mixture (AR-4000 and AR-8000) was added to the various samples and mixed. Test specimens were then fabricated in accordance with Test Method No. Calif. 304-F.

The additive Emery 6856, which is a liquid, was added to the asphalt. The amount used was 2 percent by weight of the asphalt. After mixing the aggregates and the recommended asphalt content containing Emery 6856, the asphalt concrete test specimens were fabricated, also in accordance with Test Method No. Calif. 304-F.

So that a direct comparison could be made with respect to the effectiveness of the additives, control samples were also fabricated using no additives.

### Test Results

The following tests were performed:

a. Stability - Test Method Calif. No. 304-F
b. Cohesion - Test Method Calif. No. 306-C
c. Specific Gravity - Test Method Calif. No. 308-C
d. Abrasion Resistance - Test Method Calif. No. 360-A
   100°F, rubber balls
   40°F, steel balls
e. Expansion
f. Swell - Test Method Calif. No. 305-B
g. Resilient Modulus

(1) Cechetini, J. and Sherman, G., "Investigation of Lime Slurry to Control Absorptive Aggregates Used in Asphalt Concrete".

Limited funds for this project would not permit an extensive analysis of the various mix designs; therefore, the recommended asphalt content was determined for the control series, and this recommended asphalt content was then also used for specimens containing the two additives. The limited funds did not permit laboratory personnel to duplicate all the test specimens. Duplicate tests were performed only on Surface Abrasion and Flash tests.

An examination of test results for the control specimens as presented in Tables 1 and 2 show that, of the tests performed, the material failed to meet the Sand Equivalent minimum of 45 but passed all the other routine tests. However, this material is absorptive (0.6% Mod C.K.E.) and did have a linear expansion of over 0.030".

As shown in Table 2, there is no significant difference between control tests and samples containing additives for the Swell and Specific Gravity tests; however, the lime slurry additive did reduce the stability and percent air voids, and increased the cohesion value when compared with the test results for the control specimens. The use of Emery 6856 had no significance on the characteristics tested. As shown by Table 3, the sample containing lime slurry had less abrasion loss, less expansion, and a much higher resilient modulus than both the control group and the samples containing Emery 6856. Because of the relationship between the surface abrasion test and field stripping and raveling, the effect of the lime slurry treatment is quite significant. As raveling and stripping are the types of failures being encountered, use of the lime slurry appears to be worth trying with the Bowman Pit material.

## Follow-up Condition Survey

During this fiscal year, 1974-1975, and the following fiscal year, 1975-1976, condition surveys will be made to evaluate the effect of lime slurry on the asphalt concrete pavement. The section containing the lime slurry will be compared to other asphalt concrete pavements without a lime slurry additive.

TABLE 1

74-1004

Aggregate Properties - Bowman Pit District 09

| Grading (3/4" B Med.) | | Spec. (Moving Average) |
|---|---|---|
| 3/4 | 100 | 95-100 |
| 1/2 | 83 | |
| 3/8 | 72 | 65-80 |
| No. 4 | 52 | 45-60 |
| No. 8 | 41 | 30-45 |
| No. 16 | 31 | |
| No. 30 | 22 | 15-25 |
| No. 50 | 13 | |
| No. 100 | 8 | |
| No. 200 | 5 | 3-7 |

Surf. Area = 26.9 $Ft^2$/lb.

Sand Equiv. = 38

Specific Gravity

Avg.Sp.Gr.Agg. = 2.62
Coarse Sp.Gr. = 2.57
Fine Sp.Gr. = 2.68

CKE

$K_c$ = 0.9
$K_f$ = 1.1
$K_m$ = 1.0
Bit.Rec. = AR-4000 4.8%
AR-8000 5.1%

Mod. CKE

Absorption = 0.6
Surf. Area = 33 $Ft^2$/lb.
Bit.Rec. = AR-4000 5.3%
AR-8000 5.5%

Final Asphalt Content Recommendation

AR-4000 5.8 - 6.1%
AR-8000 6.1 - 6.4%

Flash Point of Anti Strip Agent

270°F Cleveland Open Cup (AASHTO T-48)

TABLE 2

AGGREGATE FILM STRIP STUDY

| Test | % Asph. | Grade | Control | 2% Lime* Slurry | 2% Emery 6856** Anti Strip Agent | Remarks |
|---|---|---|---|---|---|---|
| Stabilometer Value (T.M. No. Calif. 304) | 5.8 | AR-4000 | 46 | 40 | 45 | |
| | 6.1 | AR-8000 | 45 | 36 | 45 | Flushed |
| Specific Gravity (T.M. No. Calif. 308) | 5.8 | AR-4000 | 2.29 | 2.31 | 2.30 | |
| | 6.1 | AR-8000 | 2.29 | 2.32 | 2.29 | |
| Cohesion (T.M. No. Calif. 306-C) | 5.8 | AR-4000 | 225 | 375 | 245 | |
| | 6.1 | AR-8000 | 290 | 465 | 225 | |
| % Air Voids | 5.8 | AR-4000 | 4.8 | 4.0 | 4.3 | |
| | 6.1 | AR-8000 | 4.4 | 3.2 | 4.5 | |
| Swell (T.M. No. Calif. 305-B) | 5.8 | AR-4000 | .001 | .002 | .001 | |
| | 6.1 | AR-8000 | .002 | .000 | .001 | |

*2% Hydrated lime by dry weight of aggregate mix.

**2% by weight of the asphalt.

TABLE 3

AGGREGATE FILM STRIP STUDY

| Test | % Asph. | Grade | Control | 2% Lime* Slurry | 2% Emery 6856** Anti Strip Agent |
|---|---|---|---|---|---|
| Film Strip (T.M. No. Calif. 302-C) | - | AR-4000 | No Strip | No Strip | No Strip |
| | - | AR-8000 | No Strip | No Strip | No Strip |
| Surf Abras Loss @ 40°F (Steel Balls) (T.M. No. Calif.360) | 5.8 | AR-4000 | 85.2 | 43.2 | 79.3 |
| | 6.1 | AR-8000 | 85.6 | 47.2 | 84.1 |
| Surf Abras Loss @ 100°F (Rubber Balls) (T.M. No. Calif.360-A) | 5.8 | AR-4000 | 18.5 | 0.6 | 13.3 |
| | 6.1 | AR-8000 | 5.3 | 0.2 | 5.8 |
| Linear Expansion in 100°F Water Bath (3 days) | 5.8 | AR-4000 | .033 | .013 | .030 |
| | 6.1 | AR-8000 | .034 | .012 | .018 |
| Resil. Modulus | 5.8 | AR-4000 | $4.23 \times 10^5$ | $5.14 \times 10^5$ | $2.70 \times 10^5$ |
| | 6.1 | AR-8000 | $5.33 \times 10^5$ | $7.48 \times 10^5$ | $4.58 \times 10^5$ |

*2% Hydrated lime by dry weight of the aggregate mix.

**2% by weight of the asphalt.